ATR for Air Force Applications

Lori Westerkamp

ATR Technology Division

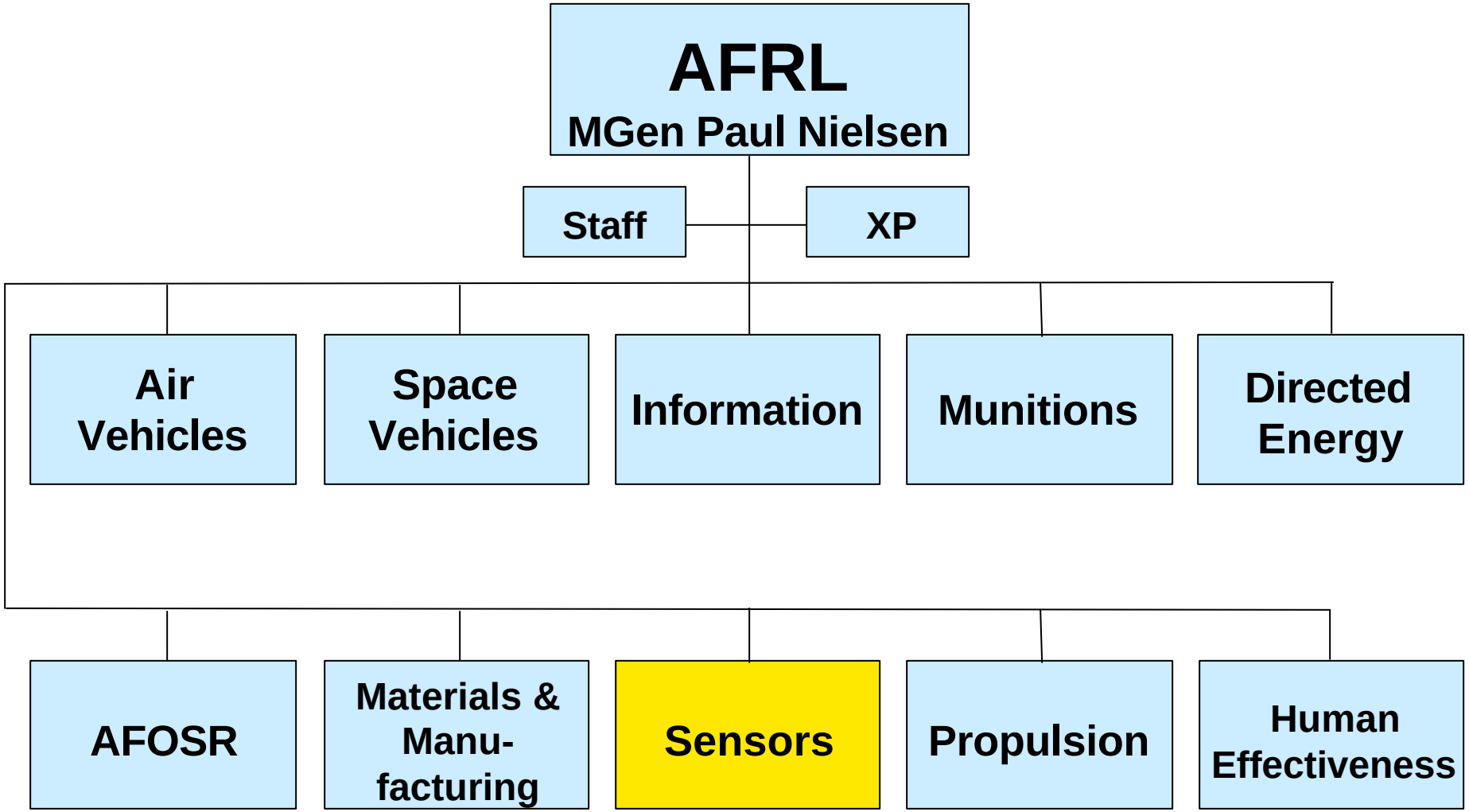
Sensors Directorate

Air Force Research Laboratory

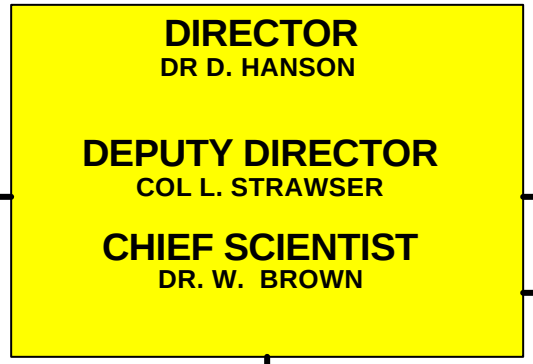
Outline

- A little about Sensors Directorate
- ATR Challenges
- ATR Approaches

AFRL
Technology Directorates



Sensors Directorate



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FINANCIAL MANAGEMENT
(SNF) MS. M. BELL

CONTRACTING
(SNK) MS. N. ADAMS

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ELECTROMAGNETIC TECHNOLOGY
(SNH)
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RF SENSOR TECHNOLOGY
(SNR)
MR. W. MOORE

EO SENSOR TECHNOLOGY
(SNJ)
COL S. PETERSEN

SENSOR AUTOMATIC TARGET RECOGNITION (ATR) TECHNOLOGY
(SNA)
MR. E. ZELNIO

SIGNATURE TECHNOLOGY OFFICE
(SNS)
MR. R. WILLIAMS

SENSOR APPLICATIONS & DEMONSTRATIONS
(SNZ)
MR. P. WESTCOTT

Sensors Directorate Locations

Rome Research Site (RRS)
Rome,NY

Wright Research Site (WRS)
Wright-Patterson AFB, OH

Hanscom Research Site (HRS)
Hanscom AFB, MA

Sensors Directorate

Our Mission

Develop technologies to collect, measure, and interpret important military information worldwide - and deny the enemy the same.

Our Vision

A full range of affordable air and space sensors, networked to the warfighter, that assure: a complete and timely picture of the battlespace; precision targeting; and threat survivability.

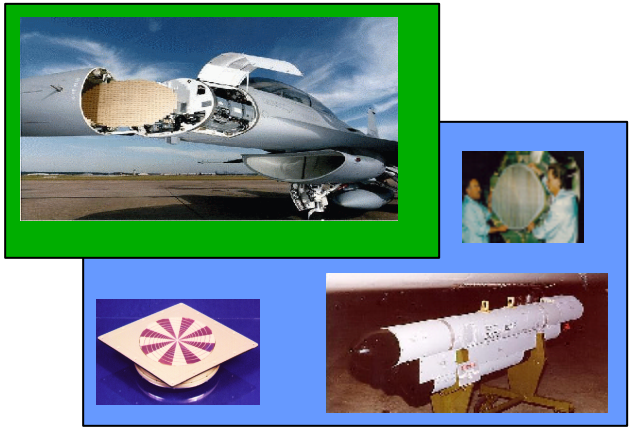
Priority Warfighter Needs
Being Addressed by Sensors Directorate

- **Sense, identify, and track all air and surface targets and threats world wide and in all weather**
- **Counter "difficult" targets (WMD, hidden, LO)**
- **Protect air and space assets**
- **Control the battlespace electromagnetic spectrum**
- **Rapidly prosecute time-critical targets and threats**

Balance: Performance & Affordability

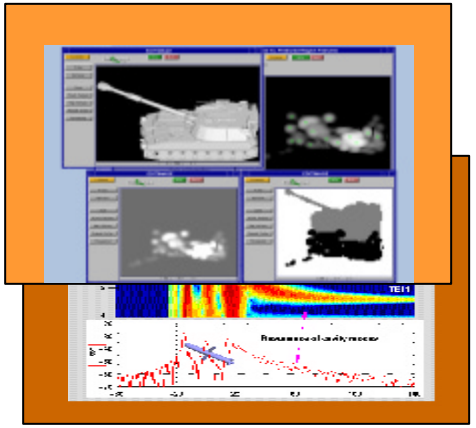
Technology Thrusts

Radio Frequency Sensors & Countermeasures



Electro-Optical Sensors & Countermeasures

Automatic Target Recognition & Sensor Fusion



Application Sub-thrusts

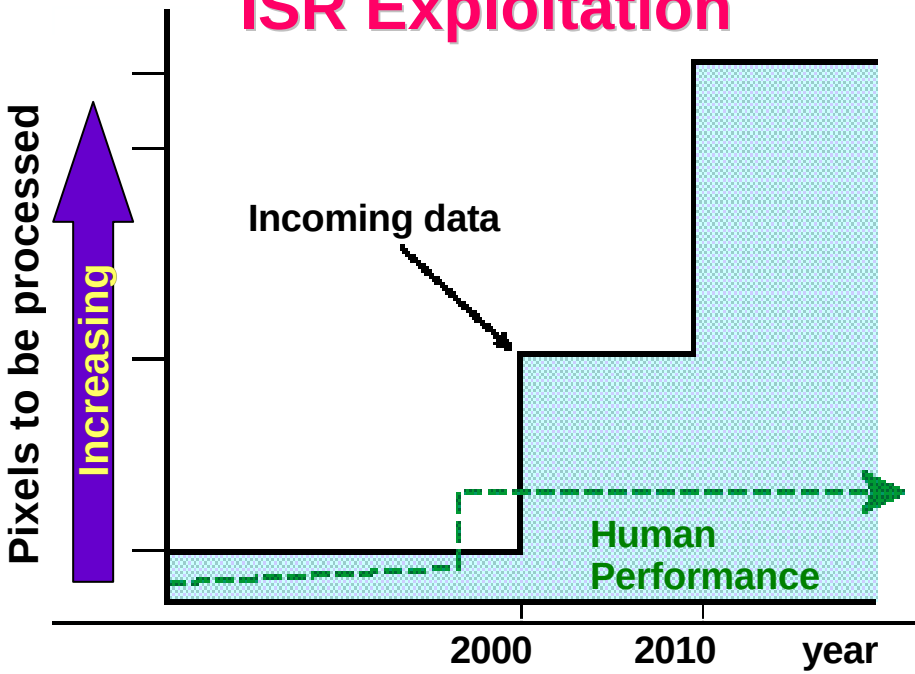
- Radar
- Assured Reference
- Electronic Warfare
- Target Detection & ID
- Threat Warning & CM
- Find, Fix, Track, and ID

Enabling Sub-thrusts

- Apertures
- Algorithms & Phenomenology
- Digital Receivers & Exciters
- Receivers
- Transceivers
- Algorithms & Phenomenology
- Innovative Algorithms
- Target Modeling and Simulation
- Evaluation and Integration

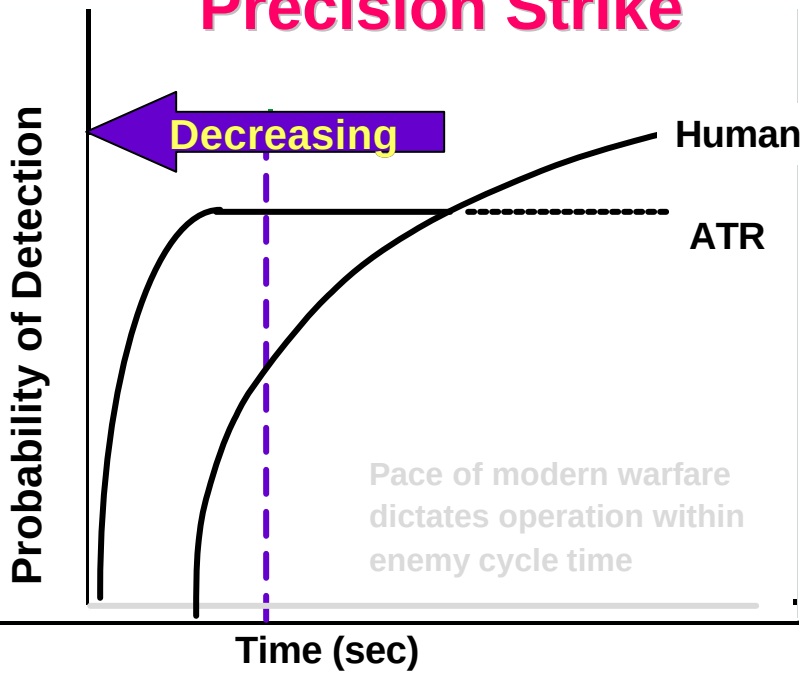
Data Quantity & Response Time Are ATR & Fusion Forcing Functions

ISR Exploitation



Data to be processed increases over 100 fold

Precision Strike



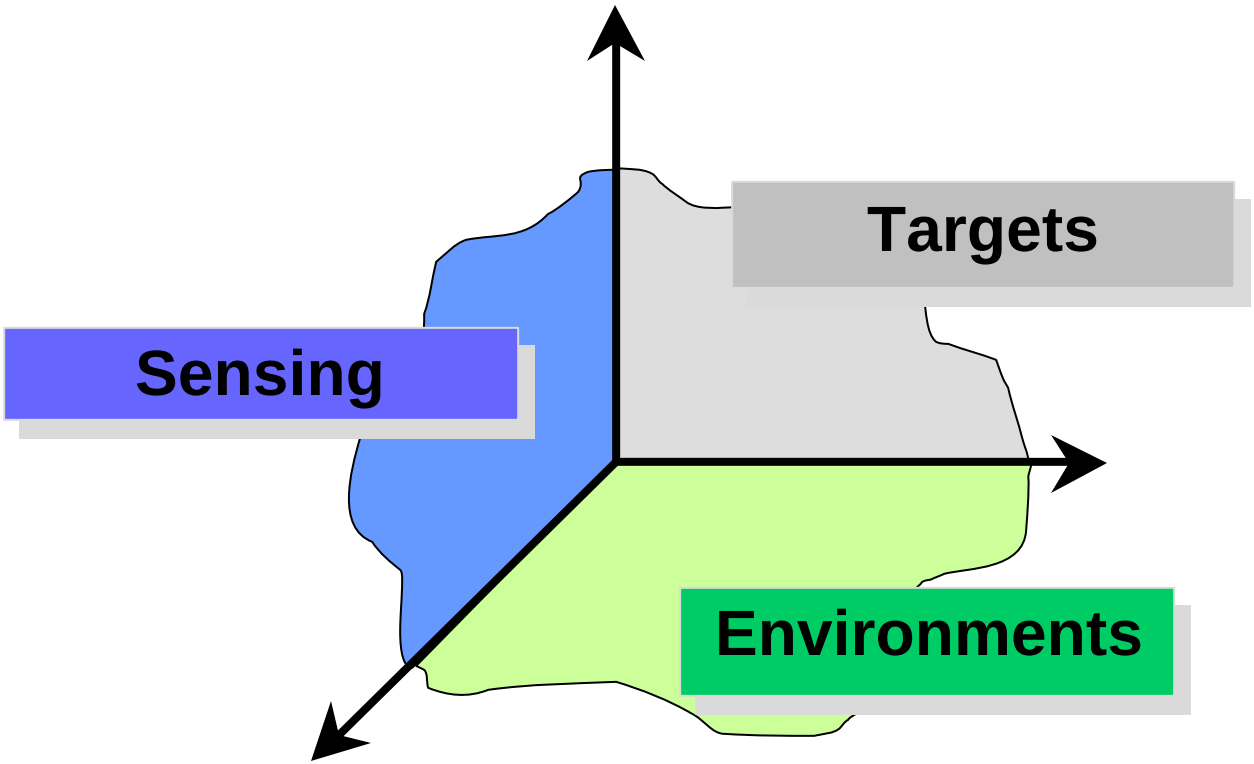
Computers are faster than people at TR

Unaided human performance is limited:

- poor at repetitive tasks
- poor at area search
- easily fatigued
- exceeds needed response time

We will be overwhelmed without ATR & Fusion

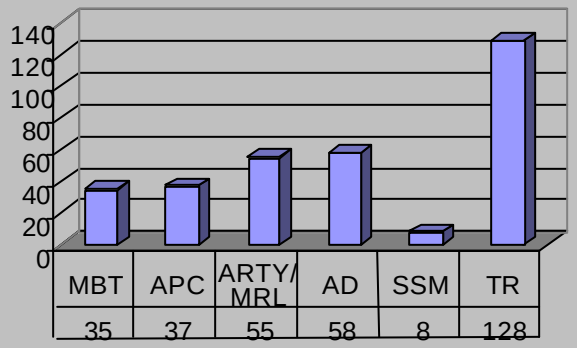
Operating Conditions

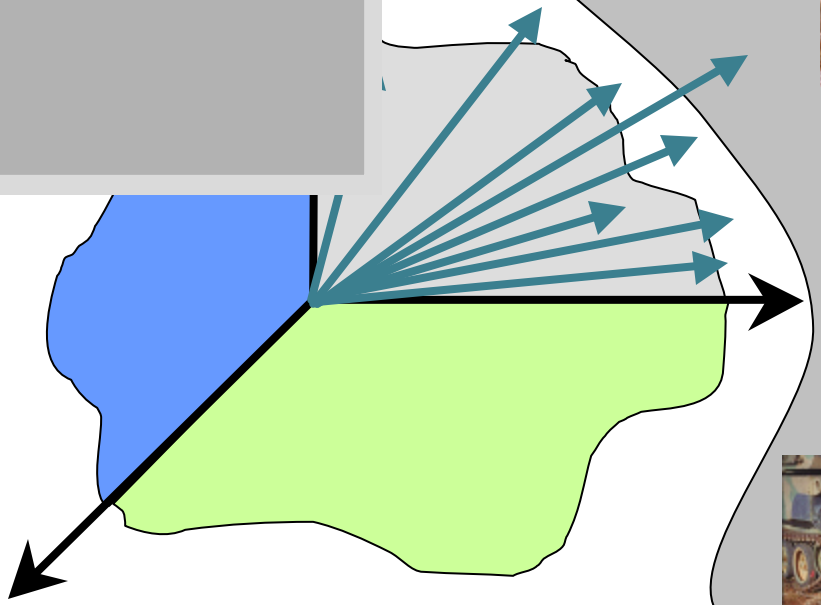


Target Operating Conditions

Targets

- Number of Classes
- Model Version Variants
- Functional Version Variants
- Configuration Variants
- Articulation Variants
- Damage
- Parts-in-Motion
- ...





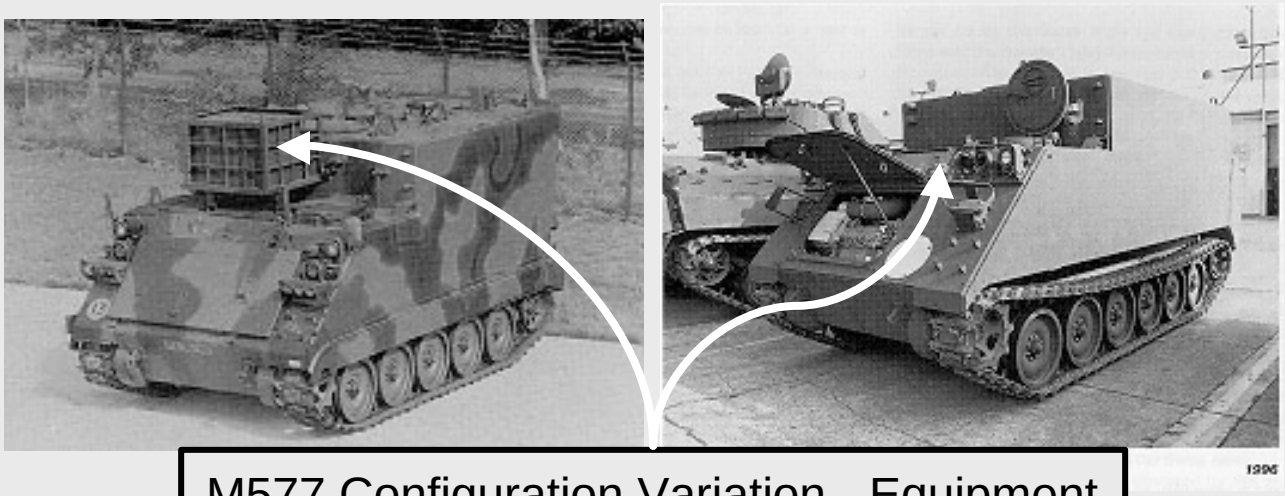
M577 and M109 Model Versions

Note the Stretch and Fuel Cells

Note Aft Turret Differences

Functional Versions - M113 Family

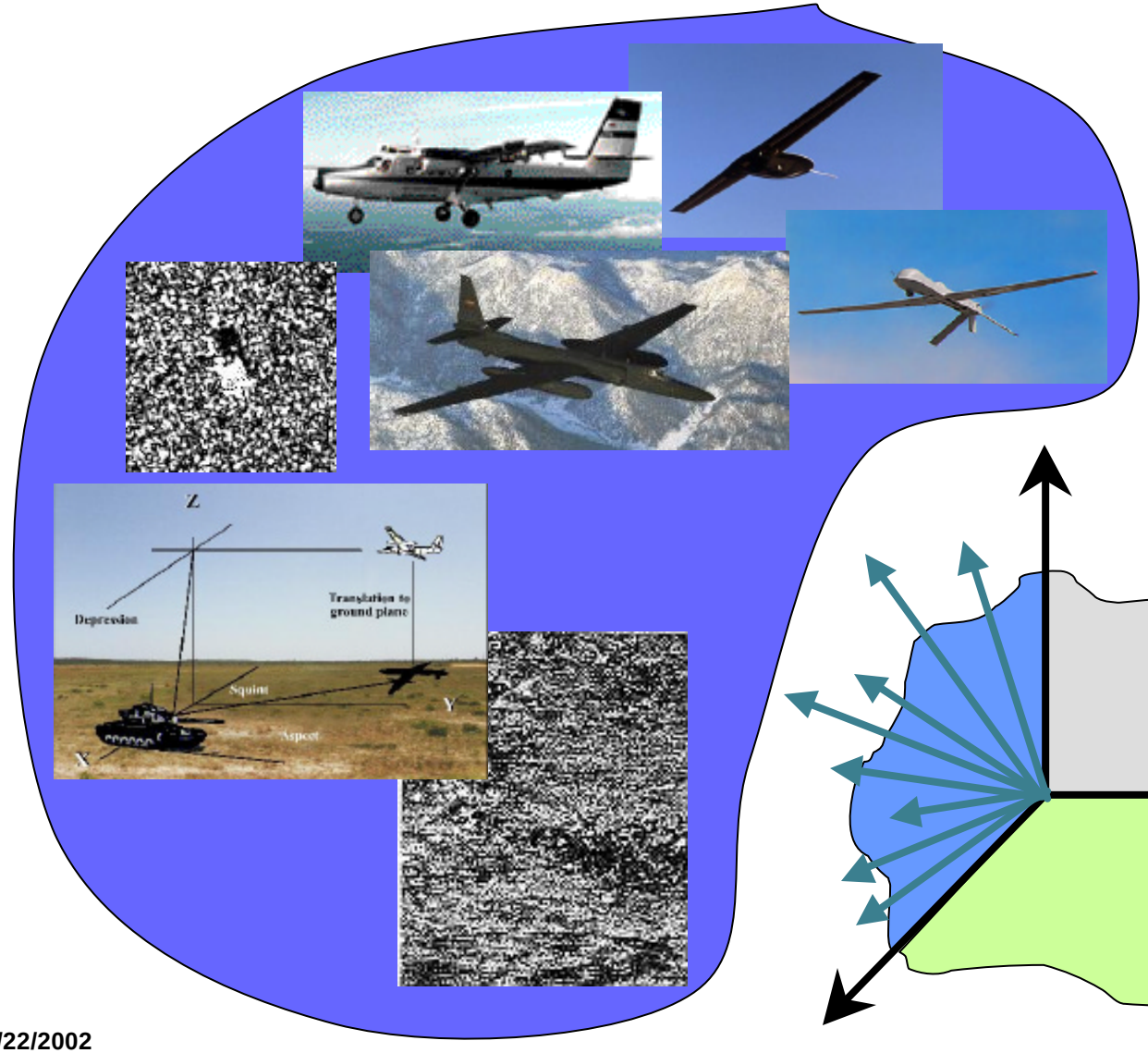
Configuration Variants Examples



M577 Configuration Variation - Equipment

T72 Configuration Variation - External Stores

Sensing Operating Conditions



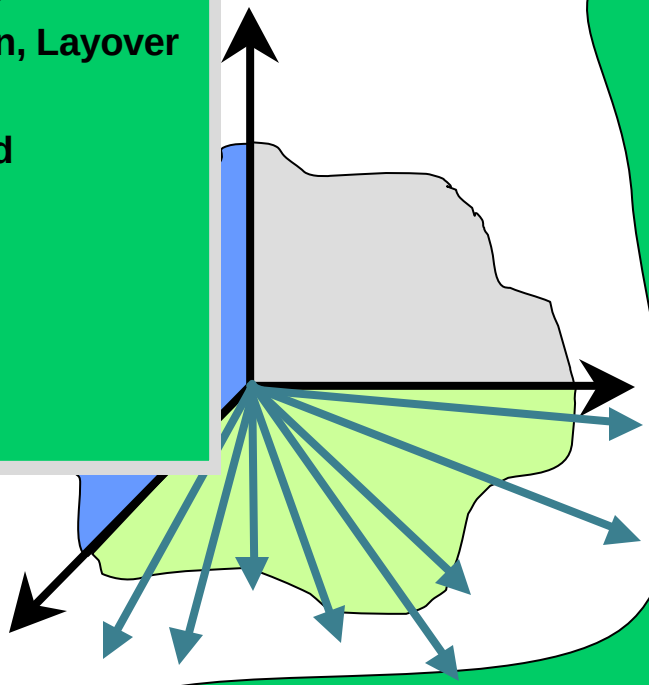
Sensing

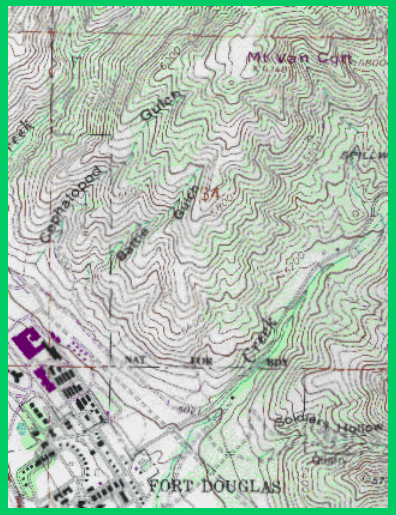
- Depression and Squint
- Frequency, PRF, BW
- Polarizations
- Single / Multi-Look
- Resolution
- Sensor Anomalies
- Noise Level
- Focusing Artifacts
- Strip vs Spot
- ...

Environment Operating Conditions

Environments

- 6 DOF Pose
- Obscuration, Layover
- Adjacency
- Background
- CC&D
- ECM / EMI
- ...



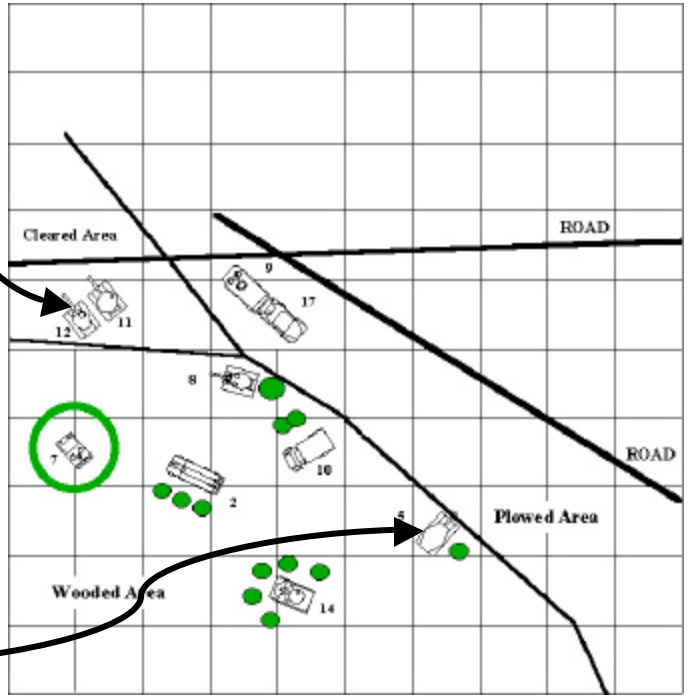


Target Obscurations

September ‘95
Redstone Arsenal, AL

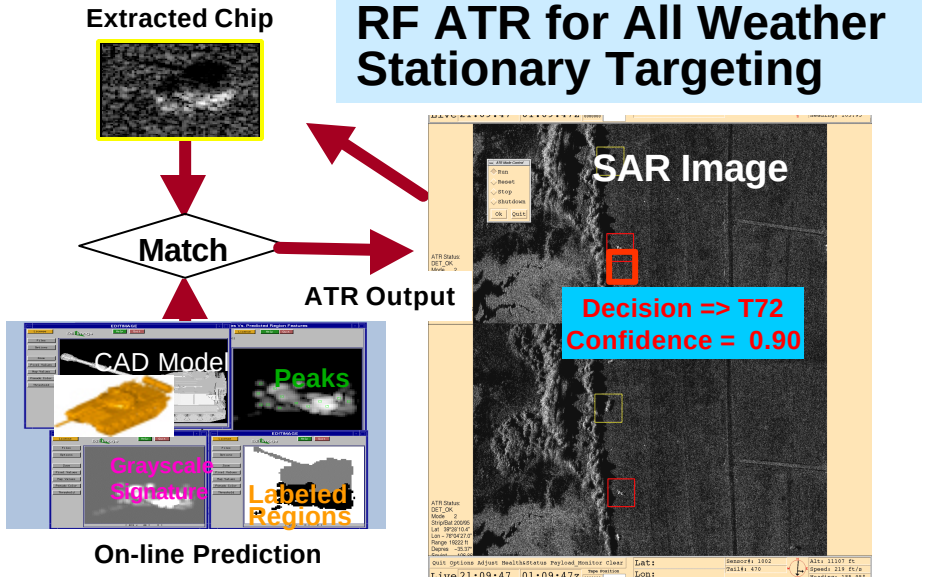
November ‘96
Eglin AFB, FL

Target Deployment

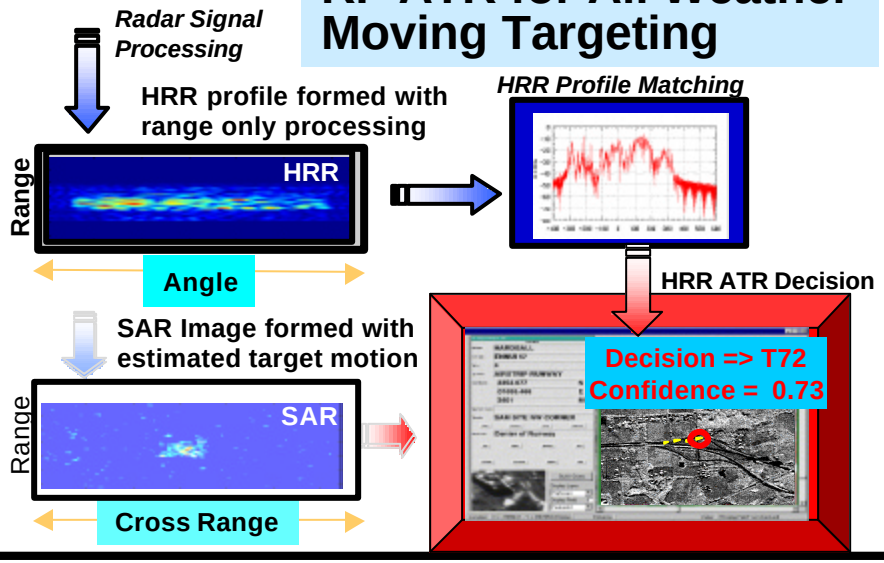


Directions for Sensor ATR & Fusion

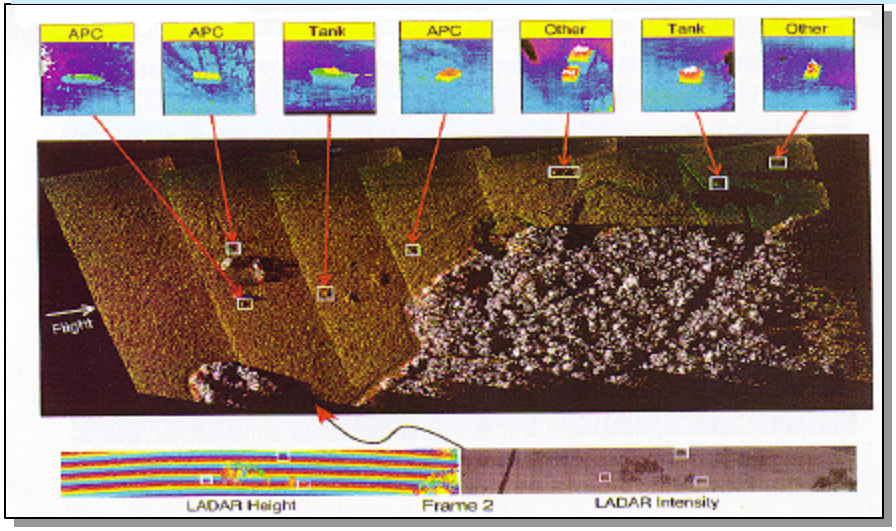
RF ATR for All Weather Stationary Targeting



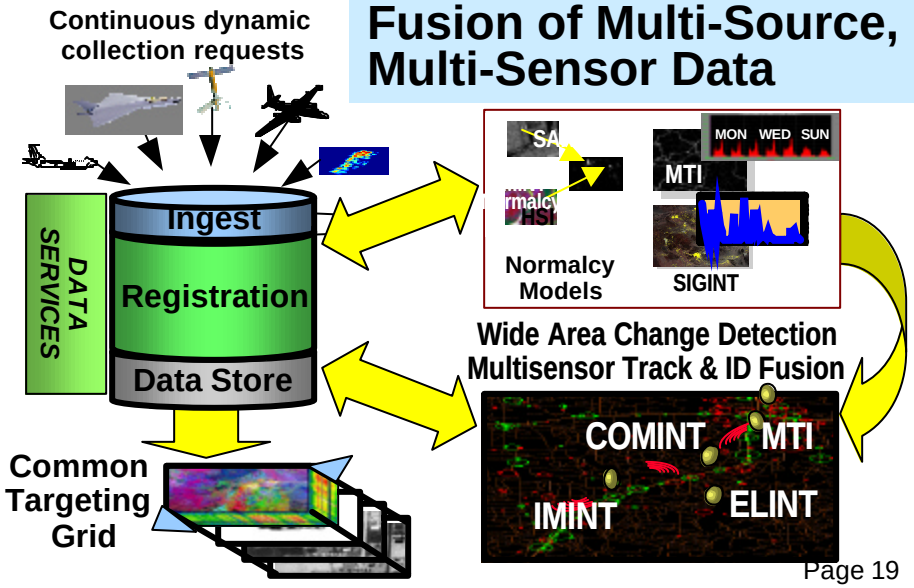
RF ATR for All Weather Moving Targeting



LADAR ATR for High Confidence ID



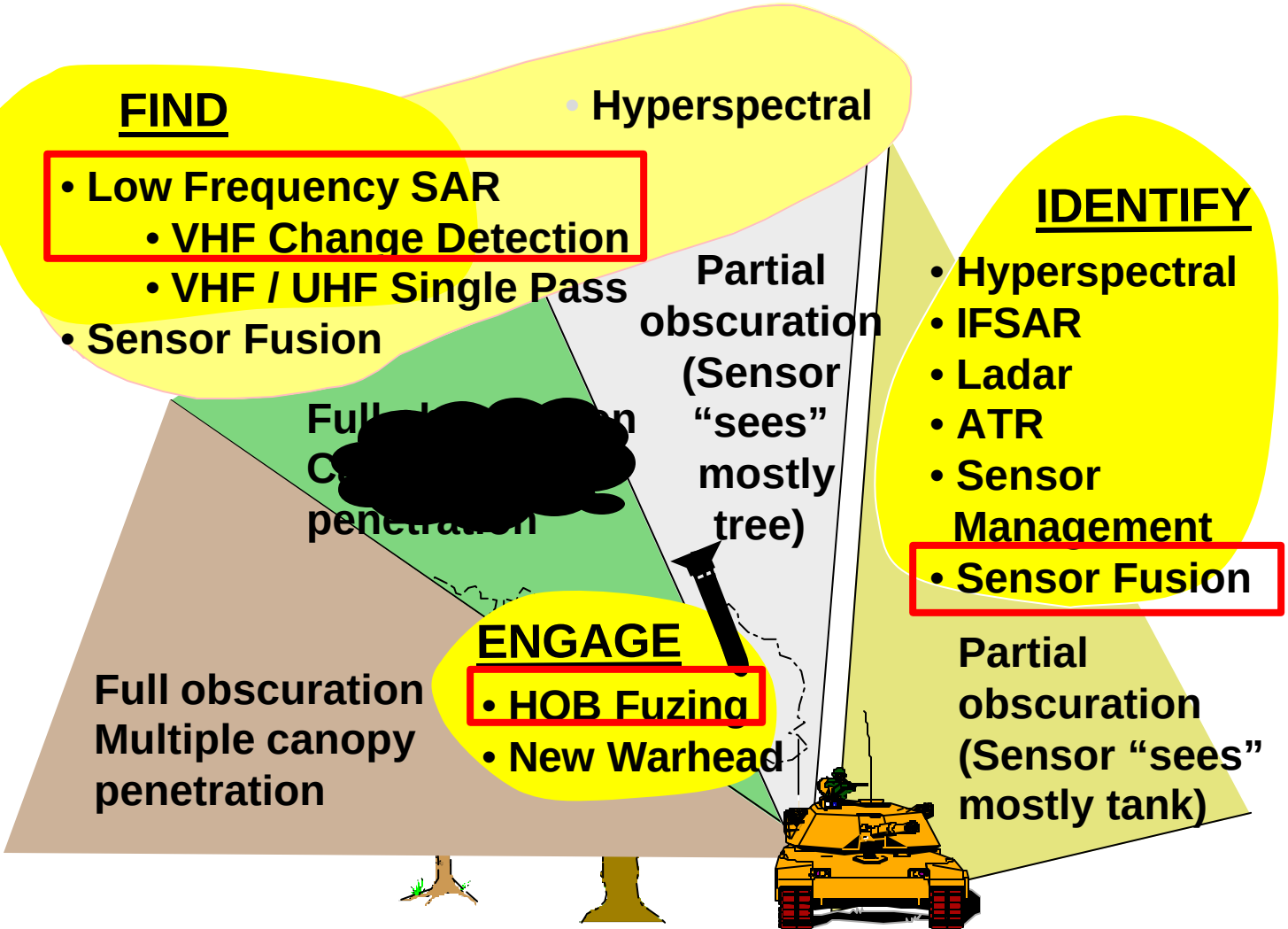
Fusion of Multi-Source, Multi-Sensor Data



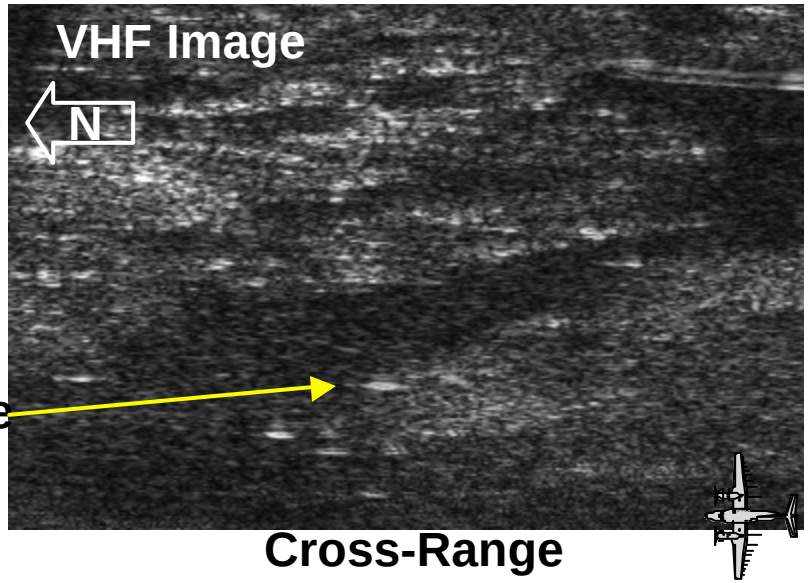
Air Force Research Laboratory

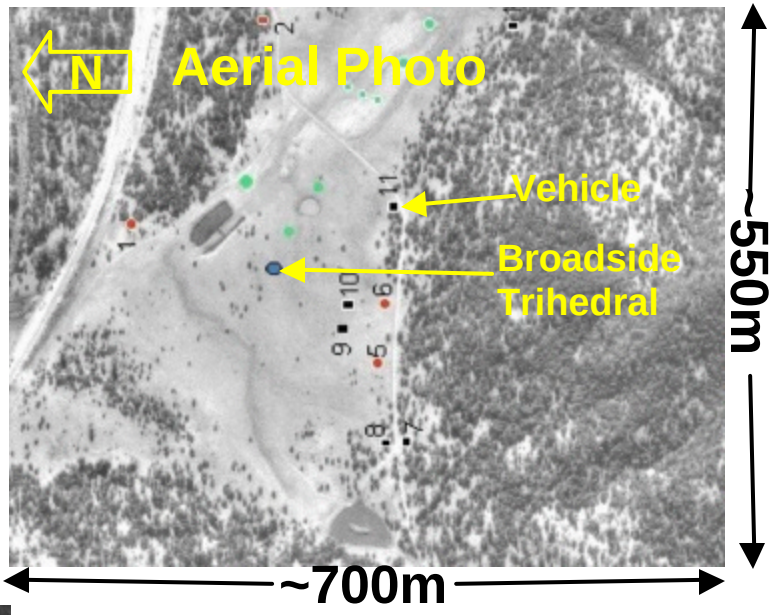
Tanks Under Trees (TUT) "70%" SOLUTION

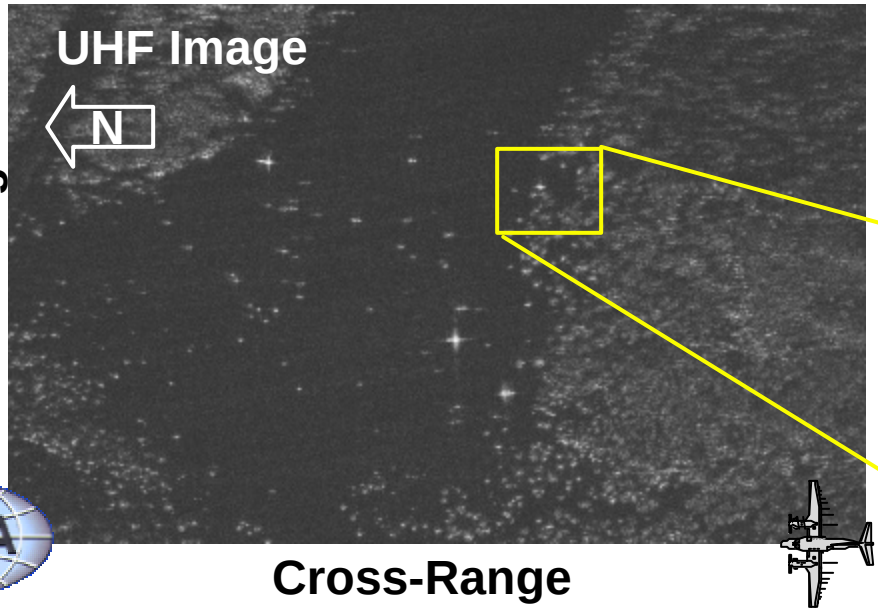
OBJECTIVE: Find, Identify & Engage Targets in Hide--Control the OPS Tempo



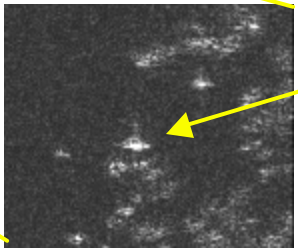
Camp Navajo Dry Run Data: Vehicle Behind Trees (May 10, 2001)







View of Vehicle from Radar



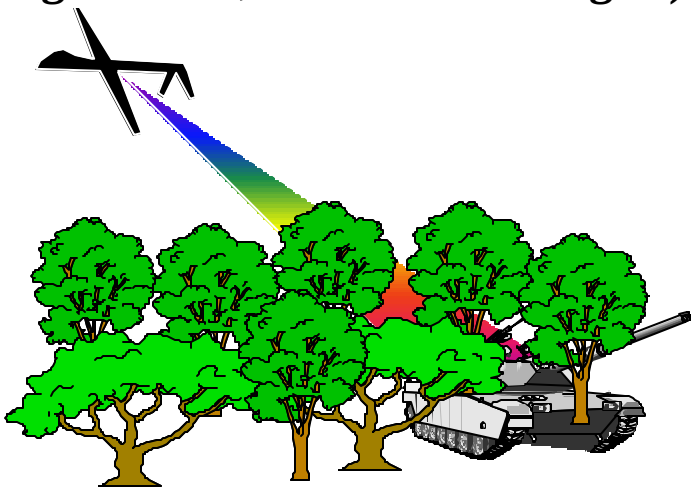
Multispectral / Hyperspectral
Sensing for Target Detection in Clutter

- **Find camouflaged and concealed targets in clutter**
  - **Wide area search**
  - **Clutter suppression to detect low contrast targets**
  - **Low false alarm rate due to color discrimination**
  - **Relaxed spatial resolution**

Target size

Traditional search pixel size (limited clutter, high contrast targets)

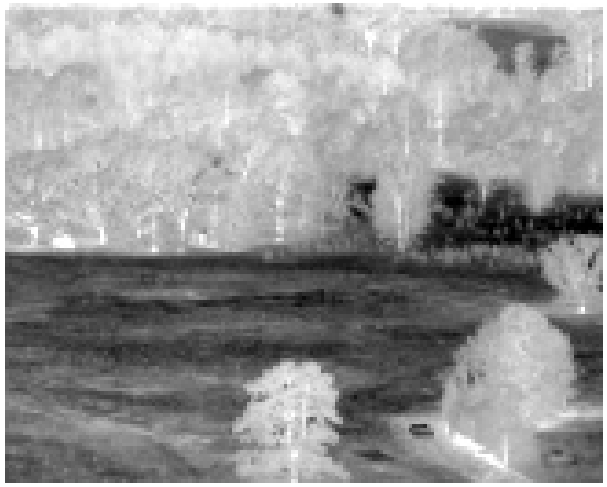
Multispectral search pixel size (high clutter, low contrast targets)



Thermal infrared (3-12 μm) operation provides day/night capabilities

HSI Proof of Concept Experiments

T-72 Tank Deployment

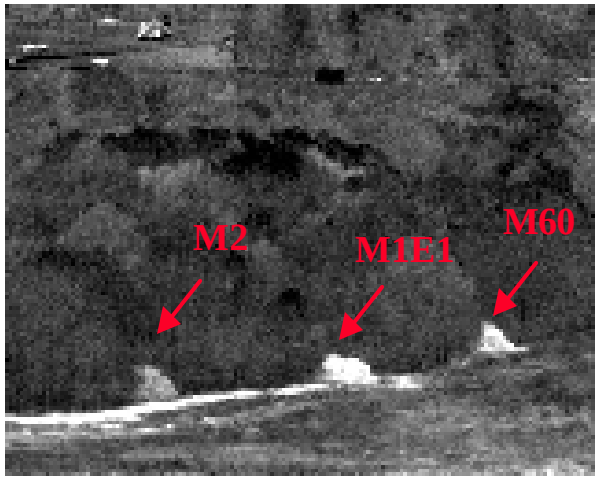


Broadband LWIR Image

HSI Clutter Rejection Filter Output

Camouflaged M2 Tank Deployment

Broadband LWIR Image



HSI Clutter Rejection Filter Output

MSI / HSI Technology Transition: Airborne Vision

SHARP (1998-2002)
- Data collection instrument
- Addresses day/night signature phenomenology
- Supports operational scenarios

SPIRITT (2000-2005)
- High altitude testbed
- Day/night HSI sensor system for ISR platforms
- Concurrent collection with SAR and SIGINT
- Supports DCGS ground architecture

JOANNA (2000-2005)
- Advanced EO/IR system for precision engagement
- Day/night MSI/HSI sensor for CC&D target detection
- Combat identification using laser imaging

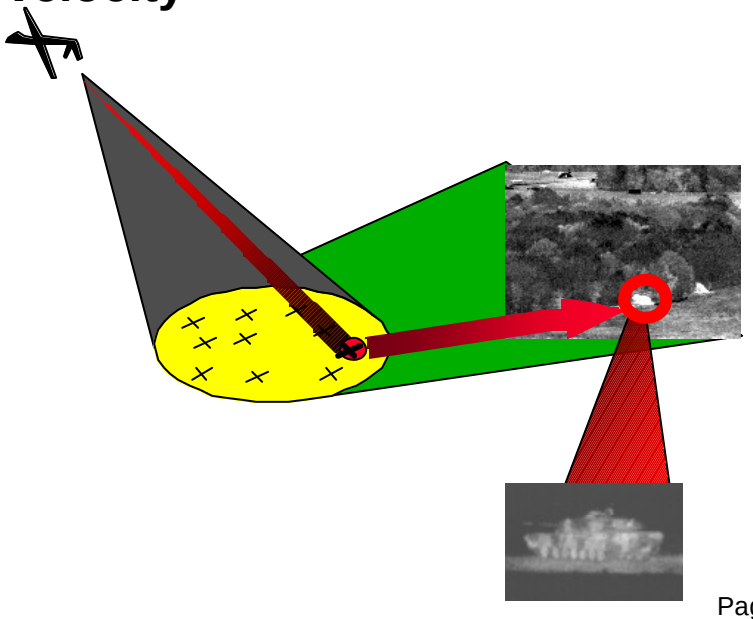
- Global Hawk EO/IR payload upgrade
- U-2 HSI payload
- ATACCS enhancement

- Advanced Targeting Pod P3I
- JSF EO/IR payload

Critical Experiments | **Advanced Technology Demonstrations** | **Technology Transition**

Multi-Dimensional Laser Radar

- **Spatial dimensions**
  - 1-D (range-profile) images
  - 2-D (reflectivity) images
  - 3-D (range/cross-range) images
  - 4-D (range/reflectivity/cross-range) images
- **Motion dimension**
  - Vibration, bulk body motion, air flow velocity
    - Spatially resolved
- **Spectral dimension**
  - Spatially resolved
- **Polarization dimension**
  - Spatially/spectrally resolved



Measure of Success:
No Sanctuary for the Enemy